

## USE OF EXPERT SYSTEMS IN CRISIS MANAGEMENT

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**Abstract** The today's change in climatic conditions results in weather phenomena occurring increasingly more frequent in Poland that can lead to crisis situations. Also the growing number of high or increased risk of serious industrial failure establishments causes greater probability of adverse and harmful effects for the environment and the population. A response to the need for minimization of those and other threats is effective crisis management. This management should be supported by IT solutions. The paper proposes to use a selected artificial intelligent method - expert systems - in the crisis management process. An expert system is a computer program adopting the knowledge and reasoning mechanisms to solve problems that require experience and expertise. The idea of expert systems is to transfer the knowledge held by a domain expert into a knowledge base, which is applied by the reasoning mechanism. The article presents some results from surveys carried out in selected local government entities of the Silesian voivodeship as regards the interest in implementation of artificial intelligence in the discussed field, and proposes an expert system for a particular crisis situation.

**Keywords:** crisis management, crisis management system, crisis situation, expert systems

### 1. INTRODUCTION

Crisis management is a set of actions including planning, decision-making, organizing, leading and controlling of the resources (whether these are human, material, non-material or financial), carried out effectively in order to achieve the intended objectives. Performance of those tasks is a multi-criteria activity, which often requires the decisions to be made under the pressure of time and the burden of a given situation. Such conditions may cause a situation to be assessed inaccurately, which may lead to a decision which is not optimum at a given moment. Therefore, it is justified to seek such solutions which regarding their counseling nature may support the decision-making process. Expert systems seem to be such a solution, as thanks to their specificity, they may be employed in uncertain situations and in circumstances which are cannot be effectively grasped in a form of an algorithm. The paper is

intended to present possibilities of using the expert systems in crisis management. This objective is implemented through literature analysis, surveys and expert evaluation of the proposed solution regarding a particular crisis situation.

## 2. EMERGENCY MANAGEMENT

Crisis management is a domain of public governance as public service, which is carried out by the local government units and play an important role in resolving crisis situations which influence safety of a local community. It is first of all related to preventing threats, preparing for their occurrence, and undertaking actions which restore stability. Crisis management has a similar meaning in the international dimension. Table 1 presents the most important selected definitions of crisis management.

Table 1  
Selected definitions of crisis management

No.	Author	Definition
1	The Act of 26 April 2007 on crisis management	Crisis management is the activity of public administration bodies, which is included in national security management, consisting in preventing any crisis situation, preparing to take over control based on planned actions, responding in the case of a crisis situation and reproducing the infrastructure or restoring its original character.
2	D. Alexander	The process of coordinating an emergency or its aftermath by communicating with participants and organising the deployment and use of emergency resources.
3	E. Lettieri, C. Masella, G. Radelli	The body of policy and administrative decisions, the operational activities, the actors and technologies that pertain to the various stages of a disaster at all levels.
4	International Federation of Red Cross and Red Crescent National Societies	The organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular preparedness, response and recovery in order to lessen the impact of disasters.

Source: own work based on (Sienkiewicz-Małyjurek, 2015)

In Poland, the crisis management is regulated by a series of documents, two of which are fundamental - the Constitution of the Republic of Poland and the Act on crisis management. Other legal regulations in this scope are acts, strategic documents and EU regulations.

There are various classifications of threats related to crisis management, regarding the context they are seen in. When it comes to their sources, a distinction is made between natural, man-made and hybrid threats (Shaluf, 2007; Ozcevk et al., 2009). Polish legal acts distinguish such threats as "a natural disaster, technical damage, act of terrorism, other local threat, mass threat, state of emergency or martial law.

A crisis management system encompasses numerous entities from both the public and private sector, which are interrelated, and which interact with each other. The crisis management system includes state administration bodies, emergency and rescue entities, non-governmental organizations, society, media, research and development institutions (Kruke and Olsen, 2012). It is commonly believed that actions related to crisis management should be undertaken on national, regional and local levels by public administration bodies (Kusumasari and Alam, 2012). In practice,

responsibility for those actions rests with the local governments, because these are the ones that know best the specificity of a place where a threat may occur (Henstra, 2010). However, despite this knowledge, the actions undertaken by the local government entities are not always effective, and they do not always allow to minimize any adverse consequences - and the reason for this may be the misinterpretation of rationale or incorrect actions. A solution contributing to implementation of crisis management task may be the use of expert systems, which are one of the artificial intelligence methods.

### 3. EXPERT SYSTEMS

An expert system is a computer application adopting the knowledge and reasoning mechanisms to solve problems that require experience and expertise (Wagner, 2017). The idea of expert systems is to transfer the knowledge held by a domain expert into a knowledge base, which is further used by the reasoning mechanism, controlled through a user interface. Expert systems are employed in situations when the obtained information is uncertain, or it is impossible to develop an algorithm solving the problem mathematically - for example in the field of technology or management. Due to the fact that the process of acquiring knowledge from experts and recording it in a form of principles within an expert system structure is labor-intensive, the effort put into creating an expert system is justified when it can be used for a long time and by a sufficiently high number of users (Ruiz-Mezcua et al., 2011)

An expert system is composed of the following elements:

- a database including a declarative form of expertise held by experts in particular domains, formulated as rules;
- a database of variables with conclusions obtained by the system during previous actions, with a possibility to reproduce the reasoning and provide explanations;
- a backbone of a system, including:
  - a knowledge base editor allowing to modify the knowledge allocated in the system,
  - a reasoning mechanism adopted in the reasoning process based on the user-defined rationale and queries,
  - an explanatory mechanism which explains, upon a user's request, the reason why the system provides a particular answer,
- a user interface used to communicate with the system by asking questions, receiving information, obtaining answers and explanations.

The expert systems, thanks to the domain expertise, allow to use this knowledge effectively numerous times, which may be of great significance in the context of actions related to crisis management (e.g. climate change and the related repeatable extreme weather events). This gives a chance to release the expert from the need of repeating similar analyses and focus the attention on other tasks. A special advantage brought by the expert systems, resulting directly from their qualities, is a knowledge engineer being capable of aggregating the expertise obtained from a large team of specialists into a single system.

### 4. RESEARCH OUTPUT

A survey questionnaire was sent to 18 communes of the Silesian voivodeship in Poland within the course of analysis of the raised problem. These communes were

not selected by accident - the consideration was given to places, where crisis situations had occurred within previous 10 years. The research was intended to assess the present condition of crisis management and the local government entities' interest in the possibility of expert systems implementation in the field of crisis management. In the first part of the research, the respondents provided some information on their assessment of the functioning of the crisis management system so far. It should be noted that the actions undertaken within the existing system allowed to minimize or remove any adverse effects of the occurred crisis situations in majority of the communes (13), while the adverse results of a crisis situation were higher than those assumed. At the same time, more than a half of the respondents (11 persons) claimed not to see any need to improve the crisis management system. Within the scope of the discussed research, attention was also drawn to the meaning of success factors in crisis management. The factors selected and described in the literature of the subject were submitted for the respondents' evaluation (Lettieri et al., 2009). This evaluation consisted in determining the importance on a scale from 1 to 10 (where 1 - the least important criterion, 10 - the most important criterion). The respondents allocated the highest score to team work and coordination, and the lowest to professionalization (Fig. 1).



Fig. 1. Importance of success factors in crisis management

Source: own work

According to the assumption, it was found out that none of the considered entities uses expert systems in the analyzed domain. The cause for this is first of all the fact that specialists in crisis management do not hold much knowledge in the field of expert systems. It is also worth noting that majority of respondents (12 communes) show some interest in implementation of the artificial intelligence solutions in crisis management. This proves that the respondents are aware of the need to support the traditional methods by IT solutions, previously not adopted in the discussed scope. Twelve respondents agree that the use of artificial intelligence in crisis management will improve the procedure. The remaining entities have no opinion (5 persons) or oppose this statement (1 person). The respondents' expectations related to the use of expert systems refer first of all to easier decision-making, reduced involvement of a human factor and observable savings in time devoted to finding an adequate solution.

## 5. PROPOSAL OF AN EXPERT SYSTEM

In the light of the above-mentioned research output, the author made an attempt to develop an expert system dedicated to making decisions on evacuation of the population from the flood area as a part of crisis management. Analysis of documentation with communal crisis management plans and direct interviews with representatives of four communes, who deal with crisis management, allowed to define ten input variables (duration of rainfall, average daily rainfall intensity, type of rainfall, range of rainfall, access to drinking water, access to food, direct threat to human life or health, human casualties, damages to communication infrastructure, weather forecasts) and a single output variable (a decision to evacuate the population). The already mentioned experts were sources of knowledge about the analyzed phenomenon - the knowledge was compiled in a form of a heuristic database of rules. The system was prepared in Cake and PC-Shell applications, included in the Sphinx artificial intelligence package. Figure 2 presents the result of the responses to a hypothetical crisis flood situation.

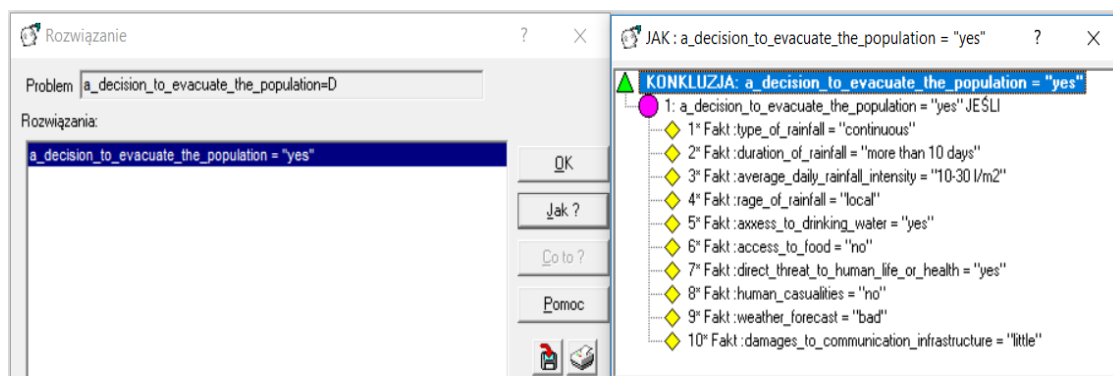


Fig. 2. A screenshot of the result of reasoning conducted by the expert system  
Source: own work based on the Sphinx package

The developed expert system was submitted for evaluation by domain experts, who took part in defining the variables and creating a database of rules. They came to a conclusion that the defined variables were appropriate for the considered crisis situation. They also noticed that the use of the expert system will determine automation of a decision-making process, which will be reflected in the speed of undertaken actions. Furthermore, the experts emphasized that reducing the contribution of a human factor by employing the proposed solution cannot lead to total elimination of human participation, because it is the human who will eventually need to make the decision and bear proper responsibility - the expert system may only be an advisor. The most important reservation considered the fact that gathering knowledge in the form of heuristic rules necessitates the use of proper data security mechanisms. They also stressed the need to analyze its utility bearing in mind any potential modifications or improvements to the proposed solution. The analysis should be carried out during the utilization phase of the expert system. This is dictated by the need to allocate relative sizable financial resources and to achieve a certain degree of stability allowing to repeat and verify the results.

## 6. CONCLUSION

Crisis management is a domain of public life, which becomes increasingly more important in the era of climate changes, industrial accidents or terrorist attacks. Correct identification of a crisis situation and taking quick and, above all, effective actions makes it necessary to seek for solutions that can improve the processes. The paper presented some possibilities of using the expert systems in crisis management. Such a solution may contribute to meeting the above postulates. This is mainly due to the fact that expert systems may be used in situation where information is uncertain, or it is impossible to mathematically represent an algorithm solving a given problem, which often happens in crisis situations that are dynamic and non-linear. The presented output from research carried out in selected communes of the Silesian voivodeship and the expert system developed on their basis is dedicated to a particular crisis situation.

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